



EVALUATING THE IMPACT OF ONSITE FOOD WASTE TREATMENT IN SINGAPOREAN SCHOOLS: A CASE STUDY OF 'LOVE YOUR FOOD @ SCHOOLS SINGAPORE' AND FUTURE PROSPECTS

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ABSTRACT

Food waste is a major issue in Singapore, making up 11% of total waste in 2023, with only 18% recycled. This paper evaluates the effectiveness of onsite food waste treatment in schools, focusing on the NEA's "Love Your Food @ Schools" initiative (2017–2019). The program introduced food waste digesters to promote composting and education. While it reduced food waste and influenced student behavior, challenges remain in sustaining long-term engagement. The study also explores future solutions like smart bins and gamification. Despite challenges, school onsite food treatment systems are a promising step toward a zero-waste nation, requiring continued innovation and community involvement.

KEYWORDS: Food Waste Treatment, Composting, Gamification, Smart Bins, Methane Emissions

INTRODUCTION

Singapore is a small land with limited space and restricted land use. In 2023, food waste made up for 11% of the entire waste produced in Singapore, yet only 18% of food waste was recycled, leaving 623,000 metric tons of food waste to be disposed of. Semakau landfill is Singapore's only landfill, and no food waste is thrown there. As a result, the majority of food waste is incinerated, and only a small remaining 10-15% is recycled and then composted with the use of food digesters (Hsien et al., 2010). Managing municipal waste becomes an issue when tied to environmental degradation. Food wastage becomes a negative behavioral habit that greatly contributes to environmental degradation through methane emissions, resource use, etc. This is often disregarded, as its effects are mostly indirect.

When the Zero Waste Master Plan was launched in 2019, it underscored Singapore's commitment to reducing waste generation and promoting recycling. Singapore's aim towards a zero-waste nation is being driven by initiatives like on-site food waste treatments in schools, making their public schools a part of their mission to achieve a zero-waste nation. On-site food waste treatment programs serve multiple purposes in reducing food waste. In addition to repurposing food waste through anaerobic digesters, these systems can challenge existing social norms and encourage students to adopt more sustainable habits.

A study by Oyenike Makanjuola, Temiloluwa Arowosola, and Chenyu Du (2020), which addresses the opportunities and challenges of food waste, talked about another study by Soma, Li, & Maclaren (2020), which highlighted consumer education as one of the most impactful solutions for addressing food waste, with the potential to divert approximately 584,000 tons of food waste annually and generate an economic value of \$2.65 billion in the United States. It went further on discussing another case study conducted in southern Italy, which illustrated how consumer behavior influences household food waste.

The study found that factors such as age and education play a significant role, with younger individuals and those with lower levels of education contributing more substantially to food waste. While this study addresses the concerns of individuals with lower levels of education contributing to more food waste, in the case of Singapore, compulsory education applies to all Singaporean citizens up to the age of 15 (MOE, 2020), making illiteracy a smaller cause of food waste in Singapore's context. This solidifies the importance of creating sustainable habits at a younger age, namely through education systems.

Community engagement has also proven effective in changing behaviors related to food waste. For instance, Yamakawa and Williams reported a 50% reduction in avoidable food waste among participants who attended community workshops, underscoring the importance of education and interaction in fostering better practices (Yamakawa et al., 2017).

In light of the importance of fostering sustainable practices in the young, this paper explores how previous onsite food waste treatment programs have reduced food waste in schools, primarily using the case study "Love Your Food @ Schools" initiative led by the National Environmental Agency. Its main objective is to prove the importance of projects like these, identify the challenges limiting its processes, and how it can be implemented in future systems, effectively making the reduction of food waste a part of Singapore's school systems. While previous reports have considered the implications food waste may have on Singapore's environment and the different ways to manage it, this paper focuses mainly on the role of schools in reducing food waste in Singapore and hopes to use this paper to increase programs in Singapore schools.

LITERATURE REVIEW

Environmental Implications of Food Wastage

Understanding why food waste is a serious issue, especially in Singapore, means looking at the process after which food

is discarded. Many overlook what happens to food waste after it is thrown away, but this phase has profound environmental, economic, and social implications, and grasping where and how this food waste is disposed of allows consumers to gain a deeper understanding of the unsustainability of food waste with our current disposal systems.

Food waste after disposal can follow multiple pathways, including landfilling, composting, biogas production, and incineration. Discarded food waste in landfills contributes significantly to greenhouse gas emissions, namely methane, which is 25 times more potent than carbon dioxide in trapping heat, as discussed in *Advances in Waste-to-Energy Technologies* (2019). Methane generation from municipal waste is a key concern, highlighting the need for better disposal methods. This is further supported by a report published by the United States Environmental Protection Agency (2023) that highlights the importance of preventing food waste being the most preferred action and further uses the quantification of methane emissions from food waste in landfills to further represent the effect that food waste has on environmental and climate degradation. It states that 58% of the fugitive methane emissions are those from the decomposition of landfilled food waste. The report discussed in *Advances in Waste-to-Energy Technologies* (2019) further goes on to discuss the usefulness of using composting in providing a more sustainable solution that minimizes methane production and creates a value-added product that can be used in agriculture. Oyenike Makanjuola, Temiloluwa Arowosola, and Chenyu Du's (2020) report, which talked about how food waste was a result of all stages of food production and the current ways food waste was being managed, further highlighted the opportunities for innovation in food waste utilization. They seconded the proposal of the integration of circular economy principles, where food waste is viewed as a resource rather than a liability. Technologies such as anaerobic digestion, composting, and the extraction of bioactive compounds offer pathways to valorize food waste. For example, vegetable peels can be processed into natural colorants, while fruit residues can serve as substrates for microbial fermentation to produce bioethanol.

The recent gamification of food waste collection methods, such as smart bins, was also highlighted, which brought out the idea of the advancement of technology playing a role in overcoming issues of behavioral change in creating more sustainable eating decisions among citizens.

METHODOLOGY

This paper uses the "Love Your Food @ Schools" governmental project to study the effectiveness of past government initiatives in reducing food waste in Singapore. It also heavily uses data from past initiatives and other reports discussing common challenges faced when holding food waste initiatives. For the "Love Your Food @ Schools" project, 10 primary and secondary schools were fitted with food waste digesters that turned discarded food into compost. These schools included Chongzheng Primary, Admiralty, Anchor Green, Greendale, Greenwood, and Punggol primary schools; Hillgrove and Broadrick secondary schools; Nan Hua High; and Dunman

High School. The 2-year-long initiative, set in 2017, was a close-looped initiative with the aim to demonstrate sustainable eating habits to students and staff in school. It included food reduction activities, which were then followed by recycling the remaining food waste into compost using food digesters planted within 10 participating schools. The project included three key aspects, which included their food reduction activities, their experimental trail, and their 'Love your food' activity.

Food Reduction Activities

Assembly talks emphasized the significance of reducing food waste, with active participation from staff, students, and even canteen stall vendors. Stall vendors contributed by segregating food waste generated during meal preparation. Additionally, the schools hosted learning journeys for neighboring schools, fostering knowledge-sharing about food waste management among students.



Source: NEA (2017).

Images 1 & 2: (Left) A stallholder at Chongzheng Primary School segregating food waste for onsite treatment. (Right) A group of Chongzheng Primary School students being taught how to segregate food waste for onsite treatment

Experiential Trail

The experiential trail featured five stations teaching students about food sustainability: rice planting to understand the effort in food production, proper buying and storage to reduce waste, mindful food consumption through a simulated buffet, donating non-perishable food to help those in need, and recycling food waste by using digesters and composting.

'Love Your Food' Activity

The "Love Your Food" activity was introduced to encourage students to clear their plates, symbolizing zero food waste. Students were tasked with capturing and submitting photos of their cleared plates via platforms like Instagram. To recognize their efforts in reducing food waste, the most creative submissions were rewarded with monetary prizes.

DISCUSSION & ANALYSIS

Reduction in Food Waste

The deployment of food waste digesters in schools has had measurable impacts on reducing food waste. For instance, Greendale Primary reported having cut the amount of food waste generated daily from 17.9 to less than 10 kg. Similarly, Dunman High School reduced the amount of food waste it produced from 20 kg to 16 kg per week (Samantha Boh, 2017).

Hypothetical Calculation of Data

A school with a population of about 1,300 students and teachers produces about 30 kg to 55 kg of food waste a day (Samantha Boh, 2017). In 2022, there were approximately 162.2 thousand students enrolled in secondary school. Assuming that the median between 30 and 55 kg is the average food waste thrown by 1,300 students, hence the total amount of food waste produced daily by secondary students: $\left(\frac{162.2}{1.3}\right) \times 42.5 = 5,302.72 \text{ kg}$. If we were to consider food waste produced by primary school students, which was reported to account for 235,116 students in 2022, this totals 397,316 primary and secondary school students in Singapore. Hence, the amount of food wasted by all students counts to $\left(\frac{397,316}{1,300}\right) \times 42.5 = 12,985 \text{ kg}$ daily. This totals the amount of food wasted annually in schools by students alone.

There's a 7.9 kg reduction from 17.9 kg to 10 kg of food waste as a result of the project, as seen in the Greendale Secondary School results. This is a 44.1% decrease in the amount of food waste produced daily. For Dunman High School, there's a 4 kg reduction from 20 kg to 16 kg a week, which is a 20% decrease in food waste produced weekly. Assuming that the mean $\left(\frac{44.1 + 20}{2}\right) = 32.05\%$ is the average decrease for all the food waste produced in all secondary schools, we can assume that is the amount of decrease in food waste generated if food digesters were implemented in secondary schools alone. Hence, food waste can be substantially reduced annually by implementing food digesters in schools.

Behavioral Changes

"A farmer appreciates farming and its output. Children too have gardening plots and corners within their school compounds, and that makes them appreciate farming and food." (Teo et al., 2019). Participation, education, engagement, and hands-on activities are among the most effective methods for encouraging school children to appreciate and avoid wasting food. Anecdotal evidence from participating schools suggests that students carry these habits into their homes, amplifying the program's impact.

Evaluation of Project

This project relied on the participation and action of many actors, which failed to sustain momentum. For years, reducing food waste at the consumer level has been a persistent challenge, and this initiative faced the same difficulties. For example, a similar project in South Korea, which aimed to reduce food waste through a "pay-as-you-throw" system using RFID-enabled bins, saw initial success but eventually declined in effectiveness due to a lack of long-term public compliance and engagement. Behavioral fatigue and resistance to change were key factors in its downfall, mirroring the challenges faced here.

One of the major obstacles limiting the success of food waste reduction initiatives is the difficulty in achieving behavioral change. This is particularly evident in school-based projects. The greatest challenge for such initiatives is keeping students consistently engaged and actively participating. Habitual cycles are hard to break; imposing a new set of practices, such

as segregating food waste after every meal, requires sustained effort, monitoring, and reinforcement.

Moreover, schools are not inherently incentivized to prioritize food waste reduction. Teachers and administrators often feel a greater obligation to focus on providing quality education, and there is less institutional pressure to reduce food waste. Instead, schools tend to prioritize more direct and manageable forms of environmental sustainability. For instance, initiatives like reducing energy use or transitioning to cleaner energy sources—such as installing solar panels or using energy-efficient appliances—are seen as more straightforward and effective. Studies have shown that reducing energy use offers significant environmental benefits while requiring less dependence on individual behavior (United Nations Environment Programme, 2022). These measures can also deliver clear cost savings over time, making them more appealing compared to labor-intensive projects like food waste segregation.

Future Outlook

Schools should reconsider placing greater importance on reducing food waste, as it is an escalating issue with far-reaching environmental consequences. Instead of taking an overly large-scale approach to eliminate food waste entirely, they can begin by targeting food waste at the canteen stall level, particularly during food preparation. For example, I initiated a composting system in my secondary school, Fairfield Methodist Secondary School, where a team of student leaders currently operates the program. Rather than relying on students to segregate their food waste, we focused on collecting food waste generated during food preparation. This waste was then brought to a food digester located at INSEAD Business School, a facility near our school, where it was processed into nutrient-rich compost for the school's community garden.

Our system has proven effective: approximately 20 kilograms of food waste is collected every 2–3 days solely from food preparation. This demonstrates that significant volumes of food waste can be recycled with relatively simple adjustments to existing processes. Schools should not underestimate the impact of small, systematic changes, which can collectively contribute to improving Singapore's environmental sustainability. Moreover, food digesters are accessible in various institutions, including the National University of Singapore (NUS), Nanyang Technological University (NTU), INSEAD Business School, and other community and private organizations. Many of these institutions offer composting services as part of their community outreach initiatives, making such systems viable for adoption in other schools.

Future Directions in Food Waste Management

Looking forward, advancements in technology present exciting opportunities for managing food waste more efficiently. For instance, the 'gamification' of food waste collection is an emerging innovation that could revolutionize waste management. Technologies such as smart bins, bin cams, and fridge cams are designed to monitor food waste and provide real-time feedback, fostering greater awareness and accountability among users. These tools not only encourage

sustainable behavior, but also collect data to optimize waste reduction strategies. (Makanjuola, Arowosola, & Du, 2020).

While the potential of these technologies is promising, their feasibility in schools and other institutions must be carefully evaluated. The cost of implementing smart waste management systems, including the installation and maintenance of smart bins, could be substantial, especially for schools operating on tight budgets. Furthermore, the scope of such initiatives must be considered—these technologies might be better suited for larger organizations or communities with higher volumes of food waste to justify the investment.

However, the future holds the possibility of these systems becoming more affordable and accessible through economies of scale or government subsidies. If schools and institutions can integrate such innovations into their operations, they may achieve both educational and environmental benefits. By teaching students to embrace technology-driven solutions to food waste, schools can nurture a generation that is more conscious of sustainable practices.

In conclusion, while schools may start with smaller initiatives like composting systems for food preparation waste, they should also consider expanding their efforts in line with technological advancements. By balancing cost, scope, and environmental impact, schools have the potential to make a meaningful contribution to reducing food waste and advancing sustainability in Singapore.

Limitations of the Research

One of the significant challenges in this study is the lack of comprehensive, longitudinal quantitative data to measure the exact impact of the 'Love Your Food @ Schools' initiative. The absence of clear metrics such as the reduction percentage of food waste, detailed behavioral tracking, and long-term follow-up data limits the ability to definitively quantify the success of the program. While anecdotal evidence from participating schools suggests positive outcomes, statistical backing is crucial to support these claims.

The initiative's evaluation period is relatively short, and without substantial long-term follow-up, it's unclear whether the habits formed during the program will persist. Understanding how schools maintain food waste reduction practices after the initiative's completion is critical to assessing its lasting effectiveness.

CONCLUSION

In conclusion, this paper explored the effectiveness of onsite food waste treatment programs in schools, with a specific focus on the 'Love Your Food @ Schools' initiative by the National Environment Agency. While there have been promising reductions in food waste and positive behavioral changes, the overall success of the program remains mixed due to several limitations. These include the lack of extensive quantitative data, challenges in maintaining long-term student engagement, and the variation in outcomes among different schools.

Despite these challenges, the initiative's impact cannot be dismissed, particularly in fostering greater awareness about food waste and providing valuable educational opportunities for students. Looking ahead, technological innovations such as smart waste management systems and the gamification of food waste collection could further enhance the program's effectiveness. However, schools should carefully balance cost, scalability, and environmental impact when implementing such technologies.

The key takeaway is that the integration of onsite food waste treatment in schools represents a valuable step towards reducing food waste in Singapore and contributing to the nation's broader goal of achieving zero waste. However, continued efforts to engage students, expand the use of technological solutions, and gather more robust data will be essential for improving and scaling the initiative in the next five years. In conclusion, while the 'Love Your Food @ Schools' project marks a promising start, its success will ultimately depend on sustained engagement, innovation, and long-term commitment from both schools and the broader community.

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